P. 150, line 2. For $1 \epsilon^2 \cos^2 \omega$ in the denominator of the last term of the value of $\frac{dm}{n}$, read $1 - \epsilon^2 \cos^2 \omega$.

P. 214. Fig. 44, the letter P out of place; compare with Germain's Fig. 98; in the letterpress "angle $APC = \omega$" should be $= \pi$.

Also the numbering of the sections seems to require some revision. Section VII. referred to in p. xiii. of the introduction, as containing Mr. Schott's account of the polyconic projection, is not of course the Section VII. of the text, and though Part II. is not divided into sections, yet in p. 230 "The Tables" appear under § xii.

PROMISE AND PERFORMANCE IN CHINESE SCIENCE

UNDER the title of "Science à la Chinoise," a writer in a recent number of the excellent *North China Herald* dwells on what may be called the disparity between the promise and the performance of Chinese science. The ancient classics contain beautiful maxims on the necessity for research into nature. The "Great Learning" tells us that knowledge is perfected by the investigation of nature; Confucius urged his pupils to study the "Book of Poetry," because, among other things, they could become acquainted with the names of plants and animals; Mencius tells us that the careful study of phenomena is the road to knowledge, and in illustration says: "Though heaven is high and the stars distant, yet, having investigated their phenomena, we can sit down and calculate their revolutions for a thousand years." It has long been a proverb among the learned that to be ignorant of a single thing is a disgrace to the true scholar, and to be ignorant of nature is as if nature did not exist. When the revered ancient sages of China, whose words are in the mouths of all, thus encourage scientific research, we should be led to anticipate great results from the patience, intelligence, and ingenuity of the Chinese. But, as in so many other respects in that anomalous country, we have excellent maxims and little more. There is, says this writer, neither research nor knowledge; science has no existence. There is indeed a considerable natural literature. From ancient times the Chinese have taken note of natural phenomena. Their record of solar eclipses is perhaps the most ancient and accurate in the world. They have more or less elaborate works on astronomy, mathematics, botany, zoology, mineralogy, physiology, and many other sciences. Yet there is scarcely any true science in them. Classification, even in regard to plants and animals, there is none. Mineralogy is mainly a description of curious stones. Nor is there any progress, for the more ancient works are generally the best, and as a consequence the Chinese to-day are as their fathers were thousands of years ago. The superstitions respecting natural phenomena, which are as living active truths to-day for all classes in China, remind us rather of man in his state of barbarism than of the ancient culture and civilisation of the Middle Kingdom. The sun and moon are to the Chinese as they were to primitive man, living things, gods to be worshipped. The stars in their courses powerfully influence, if they do not absolutely determine all human events. In them the wise may read as in a book the destiny of man and the fate of empires. Their combinations make lucky and unlucky days, and we shall do well to note carefully their signs and silent warnings. Comets are the precursors of famine, pestilence, and war—prognosticators of the wreck of empires and the fall of kings. Eclipses are the periodic efforts of the dragon fiend to destroy the lights of heaven, and every notice of an approaching eclipse sent by the Imperial astronomer to the provinces is accompanied by a Government order to employ the usual methods of gong-beating and so forth in order to rescue the threatened luminary. Again, thunder is the roar of the anger of heaven, and to be smitten by a thunderbolt is to be marked as a thing accursed. Wind is born in the heart of great mountains, whence it issues at the command of the wind-god. Most districts have their wind-mountains. That at Lung-Shan in the northern province of Chihli is the most remarkable. It has a cave at each of its four sides. The spring wind issues from the cave on the eastern side, the summer wind from the southern, and so for the others. Wind eddies or whirlwinds are raised by the hedgehog in his rapid passage from one place to another, the dust serving to screen him from the vulgar gaze. Rain is produced by the dragon god, who carries up vast quantities of water from the lakes and rivers in his capacious jaws, and pours it down in showers over the earth. Every mountain has its spirit or genius, every valley its nymph, every spring its naiad. Hence mountains and rivers, old trees and curious rocks, become objects of worship.

These and the like superstitions which enter every domain of nature are not confined to the poor and illiterate; they are shared by the rich and learned, nay, they are repeated and acknowledged by the Imperial Government itself in its decrees in the *Peking Gazette*. The highest scholar in the empire knows no more of nature than the humblest peasant. The years have come and gone, repeating the same old story, but there has been no ear to hear it, no mind to understand it. Nature has found no interpreter among the Chinese; during their long national life they have contributed nothing to science. How are we to account for this? In other fields of national effort, and especially as inventors, they must be allowed a high place. It cannot be indifference, for they have written largely on the beauties, marvels, and mysteries of nature, and many have shown keen interest in the discoveries of science. It may partly, perhaps, be due to the fact that the intellect of the nation is employed in the struggle for place and power along grooves in which science has no part. The writer we quote thinks it is mainly owing to the narrow and perverted system of education; and while the present system continues the study of science will be impossible to the youth of China. The cleverest young men find it as much as they can do to take their first degree at twenty. The higher degrees, which are also the avenues to office, can scarcely be won for years later, and thus they cannot afford a thought for anything beyond the common curriculum.

ON THE PROPERTIES OF WATER AND ICE[1]

DR. PETTERSON'S memoir is a most valuable contribution to our knowledge of the natural history of the waters of the globe. Every reader of Arctic voyages must be familiar with the variety of names attached to the different kinds of ice met with in these regions, such as "pack-ice," "bay-ice," "brash-ice," and the like. To one who has never seen them, the names convey very little information either of their appearance or of their mode of formation. Dr. Petterson's paper explains in a satisfactory and very remarkable manner the nature of the difference between the different kinds of ice.

In the first part of the work the subject is treated physically, and in the second chemically. In both parts there is much that is new and valuable.

In the Arctic Ocean, and especially in that part of it visited by the *Vega*, the saltness of the water varies much from place to place. The large rivers of Siberia constantly pour forth fresh water which lies on the surface of the ocean and spreads round the coast like a fringe. This layer often extends a considerable distance out to sea, where it gradually thins out. Nearer the shore it is thicker, but wherever the depth exceeds 20 or 30 metres the dense ocean water is found below and the two layers

[1] "On the Properties of Water and Ice." By Otto Petterson. Publication of the *Vega* Expedition. (Stockholm, 1883.)

persist without sensible mixture. As an example may be cited some observations made on board the *Willem Barents* in the Kara Sea on August 3, 1881:—

Depth, fathoms.	Temp. °C.	Density.
0	+8·2	1·006
1	+6·2	1·009
2	+1·7	1·020
3	−1·0	1·0236
5	−1·5	1·0247

Here, while we have what is practically fresh warm water at the surface, and to a depth of a fathom from it, at two fathoms we have cold Arctic Ocean water. Looking therefore to the great variety in the composition of the waters exposed to the winter cold and therefore likely to produce the ice met with in Arctic regions, Dr. Petterson has studied separately the change of heat and volume by the freezing of (1) pure water, (2) brackish water of little saltness, and (3) ocean water of ordinary saltness. With regard to the freezing of brackish or salt water no previous investigations of a quantitative character exist, and the author's results are all new. With regard to the freezing of pure water the most important investigations were those of Plücker and Geissler. While verifying their result as to the *average* coefficient of dilatation of ice, the author made the important discovery that the volume of ice *decreases* as the temperature rises, in the vicinity of the melting point. In extending his researches to brackish and salt waters he found this anomaly more and more accentuated the more salt was contained in the ice formed. Rightly seizing the importance of this very remarkable observation the author makes the behaviour of pure ice in the vicinity of its melting point one of the main objects of the investigation. The "dilatometer" used was a glass vessel of peculiar construction and of a capacity of 41 cubic centimetres. The water to be experimented on was frozen in it, so that it formed a cylinder of ice surrounded by mercury, which extended also into a capillary tube and indicated changes of volume. As the accuracy of the results depends, amongst other things, on the correctness of the determinations of the absolute dilatability of mercury; and as this is somewhat uncertain, and indeed variable, at low temperatures, the author adopted the device of Plücker and Geissler for producing a practically undilatable envelope for his experimental substance. The principle of it is very simple. The envelope is of glass with a coefficient of expansion 0·000028; that of mercury is 0·000181. If the volume of the glass envelope is to that of the mercury contained in it in the inverse proportion of their coefficients of expansion the residual volume will be constant even though the temperature vary. If the volume at 0° C. of the glass be 18·1 cc. and that of the mercury 2·8 cc the residual volume is $18·1 - 2·8 = 15·3$ cc. If the temperature is $t°$ the volume of the glass is $18·1 (1 + 0·000028t)$ and that of the mercury $2·8 (1 + 0·000181t)$, and the residual volume is $v = 18·1 - 2·8$ as before. The effect of variation in the coefficient of expansion of the mercury is thus reduced to a minimum.

When a cylinder of ice had been frozen in the instrument, it was immersed in a mercury bath, and subjected to variations of temperature, either with freezing mixtures, or, in winter, by exposure to the atmosphere.

These series of experiments were made with distilled water. The first series was made with water taken from the store jar in the laboratory. It gave a slight opalescence with nitrate of silver, and cannot therefore claim to have been pure. The ice formed by its congelation expanded with rise of temperature from −20° C. to −0°·3 C. Here it began to contract until it melted at 0° C. Two other series of experiments were made with water repeatedly distilled. The ice from it did not begin to contract till the temperature had risen to −0·03° C.

There can be no doubt, especially in view of later experiments with brackish waters, that the not chemically pure distilled water did contract at a measurable distance from its melting point. With regard to the other two samples, the temperature at which the ice began to expand with heat is so close to its actual melting point, that it is impossible to have implicit reliance in the result claimed. The author's own view will be best judged from the following paragraph (p. 282):—

"It is impossible to decide if absolutely pure water would be entirely free from this weakness or not, since we cannot assume that water which has boiled for a quarter of an hour or more in a glass vessel is absolutely free from minimal quantities of foreign substances as, for example, sodium salts, silica, &c. For my own part I am rather inclined to think that absolutely pure water, if it could be tested, would show an absolutely fixed melting point, but I think that this problem very much resembles another question still undecided, viz. is absolutely pure water a conducting or non-conducting substance for electricity?"

It would be well to repeat the experiment with pure freshly distilled water, freeing it from air by boiling *in vacuo*, which Dr. Petterson's apparatus would easily admit of. There would then be very much less risk of the glass being attacked.

Experiments made with sea-water ice proved that the property of contracting with heat, as the melting point is reached, becomes more and more marked the greater the quantity of salt in the ice. Three series of experiments were made. In the first, the ice when melted had a specific gravity of 1·0003, and contained 0·014 per cent. chlorine. It began to contract at −4° C. The second had a specific gravity of 1·00534, and contained 0·273 per cent. chlorine. It began to contract at −14° C. The third had a specific gravity of 1·0094, and contained 0·649 per cent. chlorine. It was contracting at the lowest observed temperature, −19° C.

In connection with these remarkable results it must be mentioned that at the same temperature, as, for instance, −15° C., the volume of the ice which on being melted furnishes 1 cc. water at 0° C. is less the greater the amount of salt contained in it. Sea water being an exceedingly complex body, it is to be hoped that Dr. Petterson will extend his research so as to examine in the same direction the ice formed by simple solutions of each of the more important ingredients of sea water. How different ice produced by the freezing of sea water must be from what we are accustomed to see on our lakes and ponds in winter, will be evident when we read (p. 286):—". . . The new ice which arises by sudden freezing of the calm surface of the Arctic sea is a *tough* substance, which can be wrinkled and folded by external pressure without breaking. Although it may be thick enough to bear the weight of a man, it is so plastic that a footstep makes a deep impression as in mouldable clay."

The physical part of the work closes with the investigation of the latent heat of fusion of fresh and salt ice. The result is that "the latent heat developed by the freezing of sea water is *extraordinarily inferior to that of pure water.*"

Hardly less interesting than his physical experiments, are the investigations into the chemical composition of sea water ice.

It has been very generally believed that sea-water ice owes its salinity to mechanically entangled brine, and that all that is really solid in it is pure ice. Scoresby, probably the most acute observer amongst Arctic voyagers, referring to this subject, says:—[1]

"Although I have never been able to obtain from the water of the ocean, by experiment, an ice either compact, transparent, or fresh, yet it is very probable that the retention of salt in ice may arise from sea water contained in its pores; and, in confirmation of this opinion, it may be stated that if the newest and most porous ice be removed

[1] "An Account of the Arctic Regions," Edinburgh, 1820, vol. i. p. 230.

into the air, allowed to drain for some time in a temperature of 32° or upwards, and then be washed in fresh water, it will be found to be nearly quite free from salt, and the water produced from it may be drunk."

During the Antarctic cruise of the *Challenger* the writer of this notice made some experiments to decide the question whether or not sea-water ice is a mixture of pure ice and sea water or brine. The *melting point* of salt-water ice of various sources was carefully observed, with the following results. Ice formed in a bucket of sea water over night melted at − 1·3° C. The bulk of ice formed was insignificant compared to the volume of water in which it was formed, so that this was a specimen of *bonâ fide* sea-water ice, without admixture of snow or spray. In the same way the melting point of pack-ice was determined. The freshly collected ice began to melt at − 1° C.; after twenty minutes the thermometer had risen to − 0·9°, and two hours and a half afterwards it stood at − 0·3°, having remained constant for about an hour at − 0·4°. Another portion of the ice rose more rapidly in temperature, and when three-fourths of the ice was melted, the thermometer stood at 0° C. In the case of the ice frozen in the bucket, the melting point remained constant for twenty minutes at − 1·3°, after which no observations were made, so that we do not know if this ice, formed under the most favourable circumstances, showed the same irregularities as the pack-ice, picked up out of the sea; but as the bulk of ice experimented on did not much exceed 10 cubic centimetres, the greater part of it must have melted in the twenty minutes. Indeed as the amount of ice formed in the bucket did not sensibly alter the composition of the water left liquid, there seems to be no reason why the ice should not be a homogeneous substance.

Adhering brine can have no influence on the melting point of ice, consequently, if sea-water ice consists of pure ice with entangled brine, it must melt at 0° C. If its melting point is different from 0° C. then the solid matter of the ice is not pure ice. We have seen that frozen sea water has a melting point of − 1°·3, which is fairly constant, and that pack-ice, which must necessarily be formed by the freezing of salt water, the congealing of spray, and the accumulation of snow, begins to melt about − 1°, the temperature gradually rising as the constituents of lower melting point are liquefied. It is thus readily apparent how it is that Scoresby found that such ice "allowed to drain for some time in a temperature of 32° or upwards," produced in the end potable water. The salt-water ice of low melting point effectually prevents the intermingled snow from melting, which finally remains practically intact, and of course can be drunk on being melted.

Dr. Petterson on purely chemical grounds comes to the same conclusion. He says (p. 303): "Those who support the common theory that sea ice is in itself wholly destitute of salt, and only mechanically incloses a certain quantity of unfrozen and concentrated sea water, must confess that we in this case ought to find by chemical analysis exactly the same proportion between Cl, MgO, CaO, SO_3, &c, in the ice and in the brine as in the sea water itself." That this is not the case is shown by a number of analyses of sea-water ices in which the proportion of Cl : SO_3 varied from 100 : 12·8 to 100 : 76·6, the average proportion in sea water being 100 : 11·88. The results of his investigations may be summarised as follows:—

Ocean water is divided by freezing into two saliniferous parts, one liquid and one solid, which are of different chemical compositions. Taking the relation Cl : SO_3 as standard of comparison, the most striking feature of the freezing process is that the ice is richer in sulphates, and the brine in chlorides. The extraordinary variation, both in saltness and in chemical composition of every individual specimen of sea ice and sea brine, shown by the tables, depends on a secondary process, by which the ice seems to give up its chlorides more and more, but to retain its sulphates. Hence the percentage of chlorine is no indication of the saltness of the ice, though it may to a certain extent be taken as an index of its age.

In connection with this part of the subject, the author cites Prof. Guthrie's work on Cryohydrates, and gives the following table:—

Cryohydrate of	Contains	Solidifies at
NaCl	76·39 per cent. water	− 22° C.
KCl	80·00 ,, ,,	− 11°·4 C.
$CaCl_2$	72·00 ,, ,,	− 37° C.
$MgSO_4$	78·14 ,, ,,	− 5°·0 C.
Na_2SO_4	95·45 ,, ,,	− 0°·7 C.

Supposing that these cryohydrates are formed in the freezing of sea water, it is easy to see how, as the temperature rises, the chlorides melt out first and leave the ice richer and richer in sulphates.

Before concluding this notice, attention must be called to a statement in a note at the foot of p. 318: "As a thermometer immersed in a mixture of snow and sea water, *which is constantly stirred*, indicates − 1°·8 C., we may regard," &c. This can be true only if the temperature of the atmosphere is − 1°·8 C.; if it is 0° C. or higher, the temperature of the sea water will assuredly rise to the melting temperature of snow, or 0° C.

Even though it should turn out that chemically pure ice does, as the author suspects, melt suddenly without previous contraction *as ice*, the discovery of the existence of a *minimum density point* of ice, not chemically pure, which includes all the ice on the globe, is one of the very highest importance.

It is to be hoped that we shall soon have a further instalment of work on a subject so large and so important, and with which the author has shown himself so well qualified to deal.

J. Y. BUCHANAN

THE STABILITY OF MERCHANT STEAMSHIPS

I PROPOSE to state, and in part to restate, the more important scientific considerations concerning the stability of merchant steamships which the investigation of the *Daphne* disaster has brought to light, following the main lines of the second part of my Report, which has been published *in extenso* in several newspapers. In this case, as in all cases touching the complicated question of ship stability, it is very necessary to be careful not to draw hasty inferences or any inferences at all which are not strictly deducible from the facts or principles established.

It is desirable to guard the reader in the first place against considering the cases of the ships *Daphne* and *Hammonia*—which I have had occasion to associate somewhat closely in my Report—as identical in more than a certain number of features, there being other features in respect of which there is little or no resemblance. I will presently point out both the resemblances and the differences, but first let me remind the reader unfamiliar with naval science what is meant by a curve of stability, quoting the Report as far as may be necessary for the purpose. Fig. 1 may be taken as the transverse section of a vessel inclined at an angle of 15 degrees to the upright. The total weight or gravity of the vessel will act downwards through the centre of gravity G, and the total buoyancy will act upwards through the centre of buoyancy B, as the arrows indicate. It will be obvious that the vessel cannot rest in the inclined position with these forces and no other operating upon her; she must revolve until gravity and buoyancy act in the same vertical line, but in opposite directions. The further she is inclined the more will the ship be immersed on one side and emersed on the other, and therefore the further out will the centre of buoyancy move. Now as neither the gravity nor the buoyancy need be altered in amount by mere inclination,